

## APPLICATION FOR PATENT

Inventor: Dov Moran

Title: ELECTRONIC MODULE WITH DUAL CONNECTIVITY

**This is a continuation-in-part of U. S. Provisional Patent Application Ser. No. 60/490,973, filed July 27, 2003.**

### FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to an electronic module adapted to be operationally connected to a larger electronic device in either of two different ways and, more particularly, to an electronic module adapted to be connected to a printed circuit board (PCB) either robotically or manually.

PCBs are used extensively in the electronics industry. Using PCBs, manufacturers in all segments of the electronics industry employ techniques that originated in the printing industry for mass production of electronic parts. A typical PCB bears mounted thereon solid-state modules and passive modules that are interconnected by conductive wires imprinted on the PCB. Often, a smaller PCB is mounted as a module on a larger PCB.

When a module is mounted on a PCB, the module is physically and electrically connected to the PCB by a suitable permanent or temporary connection. There are two types of such connections in common use: connections designed for robotic installation using surface mounting technology (SMT), and connections designed for manual assembly.

Figure 1 is a high level schematic block diagram of a prior art electronic module **10** designed for SMT assembly. Module **10** includes an electrically insulating plastic body **5** that bears electronic circuitry **4** and a ball grid array (BGA) **1**.

Electronic circuitry **4** and BGA **1** are operationally connected by a plurality **9** of wires that provide electrical power supply and signal transfer. The number of wires in plurality **9** is determined by the application that uses electronic circuitry **4**. For each of the wires of plurality **9**, BGA **1** has a tiny solder ball of hemispherical shape.

5 Module **10** is mounted on a compatible PCB (not shown) by an SMT robot that places module **10** in the correct position relative to the PCB, with the solder balls of BGA **10** in contact with matching electrical connectors on the PCB, and then melts the solder balls to form an electrical connection between the solder balls' respective wires and the matching electrical connectors. Figure 2 is a top view of an exemplary electronic  
10 module **10**. Body **5** of module **10** of Figure 2 bears an exemplary set of four solder balls **1A** through **1D**. Figure 3 is a side view of module **10** of Figure 2, showing solder balls **1C** and **1D**, body **5** and electronic circuitry **4**. Balls **1A-1D** are connected to electronic circuitry **4** by a set **9** of four respective wires that span body **5** and so are not visible in Figures 2 and 3.

15 Figure 4 is a high level schematic block diagram of another prior art electronic module **20** designed for manual assembly. Module **20** includes an electrically insulating plastic body **5** that bears electronic circuitry **4** and a plug **2**. Electronic circuitry **4** and plug **2** are operationally connected by a plurality **9'** of wires that provide electrical power supply and signal transfer. The number of wires in plurality  
20 **9'** is determined by the application that uses electronic circuitry **4**. For each of the wires of plurality **9'**, plug **2** has an elongated, electrically conducting pad. Module **20** is mounted manually on a compatible PCB (not shown) by plugging plug **2** into a matching socket that is mounted on the PCB, thereby bringing each pad of plug **2** in contact with a matching electrically conducting pad in the socket. Figure 5 is a top  
25 view of an exemplary electronic module **20**. Body **5** of module **20** of Figure 5 bears

an exemplary set of four pads **2A-2D**. Figure 6 is a side view of module **20** of Figure 5, showing pad **2D**, body **5** and electronic circuitry **4**. Pads **2A-2D** are connected to electronic circuitry by a set **9'** of four respective wires that span body **5** and so are not visible in Figures 5 and 6.

5 Sometimes, it is desirable to manually mount a module **10**, that is intended for robotic mounting, on a PCB, for example for prototyping or testing. Alternatively, a manufacturer may desire to integrate an off-the-shelf module **20**, that was originally intended for manual mounting, in an automated production line in which electronic modules are mounted robotically on PCBs. In either case, according to the prior art,  
10 an adapter component would have to be added to the module **10** or **20**, to convert the assembly method from robotic to manual or from manual to robotic. In the case of integrating a manual module **20** in an automatic production line, this also entails adding another production step. Furthermore, the PCB, on which the module **10** or **20** is to be mounted, may not have room for the adapter component.

15 There is thus a widely recognized need for, and it would be highly advantageous to have, an electronic module with dual connectivity, so that the module could be mounted on a PCB board either robotically or manually.

#### SUMMARY OF THE INVENTION

20 The present invention provides an electronic module with dual connectivity that allows selectably connecting the module by one of two different methods, for example either robotic or manual assembly, without the need for an adapter.

According to the present invention there is provided an electronic module, including: (a) electronic circuitry; (b) a first connection mechanism, operationally  
25 connected to the electronic circuitry, for mounting of the electronic module by a first

method; and (c) a second connection mechanism, operationally connected to the electronic circuitry, for mounting of the electronic module by a second method different from the first method.

A basic electronic module of the present invention includes electronic circuitry  
5 and two different connection mechanisms. Both connection mechanisms are operationally connected to the electronic circuitry. The first connection mechanism is for mounting the electronic module within a larger electronic device (and typically on a PCB) by a first method. The second mechanism is for mounting the electronic module within a larger electronic device (again, typically, on a PCB) by a second  
10 method that is different from the first method. Preferably, the first method is robotic mounting and the second method is manual mounting.

Preferably, either the first connection mechanism, or the second connection mechanism, or both, are directly operationally connected to the electronic circuitry, for example by one or more wires that directly connect the connection mechanism(s)  
15 to the electronic circuitry. Alternatively, the first connection mechanism is directly operationally connected to the electronic circuitry and the second connection mechanism is directly operationally connected to the first connection mechanism, but is only indirectly operationally connected to the electronic circuitry via the first connection mechanism. Under yet another alternative, the second connection  
20 mechanism is directly operationally connected to the electronic circuitry and the first connection mechanism is directly operationally connected to the second connection mechanism, but is only indirectly connected to the electronic circuitry via the second connection mechanism.

Preferably, the first connection mechanism includes one or more substantially  
25 hemispherical solder balls. Preferably, the second connection mechanism includes

one or more electrically conducting pads. More preferably, the first connection mechanism includes one or more substantially hemispherical solder balls and the second connection mechanism includes a like number of electrically conducting pads. Most preferably, the solder balls are paired up with respective electrically conducting pads, and are operationally connected to their respective electrically conducting pads by respective wires.

Preferably, the electronic module also includes an electrically insulating (*e.g.* plastic) body on which the electronic circuitry and the two connection mechanisms are mounted. More preferably, the two connection mechanisms are mounted on the same side of the body.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 is a high level schematic block diagram of a prior art electronic module designed for robotic assembly;

FIG. 2 is a top view of an exemplary embodiment of the prior art electronic module of FIG. 1;

FIG. 3 is a side view of the exemplary embodiment of FIG. 2;

FIG. 4 is a high level schematic block diagram of a prior art electronic module designed for manual assembly;

FIG. 5 is a top view of an exemplary embodiment of the prior art electronic module of FIG. 4;

FIG. 6 is a side view of the exemplary embodiment of FIG. 5;

FIG. 7 is a high level schematic block diagram of an electronic module of the present invention;

FIG. 8 is a top view of an exemplary embodiment of the electronic module of FIG. 7;

5 FIG. 9 is a side view of the exemplary embodiment of FIG. 8.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is of an electronic module that can be mounted in a larger electronic device by one of two different methods. Specifically, the present  
10 invention can be mounted on a PCB either robotically or manually.

The principles and operation of an electronic module according to the present invention may be better understood with reference to the drawings and the accompanying description.

Returning now to the drawings, Figure 7 is a high level schematic block  
15 diagram of a preferred embodiment **30** of an electronic module according to the present invention that can be mounted either robotically or manually. Module **30** includes an electrically insulating plastic body **5** that bears electronic circuitry **4**, a BGA **1** and a plug **2**. Electronic circuitry **4** and BGA **1** are operationally connected by a plurality **9** of wires that provide electrical power supply and signal transfer. The  
20 number of wires in plurality **9** is determined by the application that uses electronic circuitry **4**. Plug **2** is operationally connected to BGA **1** by a plurality **7** of wires. When module **30** is mounted on a compatible PCB (not shown) by an SMT robot, each solder ball of BGA **1** is melted to form an electrical connection between the solder ball's respective wire and matching electrical connectors on the PCB. When  
25 module **30** is manually plugged into a compatible socket of a PCB (not shown), each

pad of plug **2** comes into electrical contact with a matching pad that is part of the socket, establishing electrical contact between the PCB and electronic circuitry **4** via wire pluralities **7** and **9**. Figure 8 is a top view of an exemplary electronic module **30**. Body **5** of module **30** of Figure 8 bears an exemplary set of four solder balls **1A-1D** and an exemplary set of four pads **2A-2D**, interconnected by four printed wires **7A-7D**. Figure 9 is a side view of module **30** of Figure 8, showing solder balls **1D** and **1C**, pad **2D**, body **5** and electronic circuitry **4**. Solder balls **1A-1D** and pads **2A-2D** are connected to electronic circuitry **4** by the four wires of plurality **7** and by the four wires of plurality **9**. The four wires of plurality **7** are flush with the top of body **5** and so are not visible in Figure 9. The four wires of plurality **9** span body **5** and so are not visible in Figure 9.

In the preferred embodiment of Figures 7-9, BGA **1** is directly operationally connected to electronic circuitry **4**, and plug **2** is directly operationally connected to BGA **1**. Plug **2** is indirectly operationally connected to electronic circuitry **4**, via BGA **1**. This preferred embodiment is only exemplary. Many variations are possible within the scope of the present invention. In one such variation, plug **2** is directly operationally connected to electronic circuitry **4**, and BGA **1** is directly operationally connected to plug **2**, so that BGA **1** is indirectly operationally connected to electronic circuitry **4**, via plug **2**. In another such variation, both BGA **1** and plug **2** are directly operationally connected to electronic circuitry **4**. Furthermore, BGA **1** and plug **2** are only examples of, respectively, a robotic connection mechanism and a manual connection mechanism. The robotic connection mechanism of the present invention may be any type of electrical connection that allows robotic assembly. The manual connection mechanism of the present invention may be any type of electrical connection that allows manual assembly.

It also will be appreciated that electronic module **30** may be any component, device or sub-assembly that requires operational connection to a larger electronic device, and that connection to a PCB is only a typical example of such operational connection.

5           While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made.